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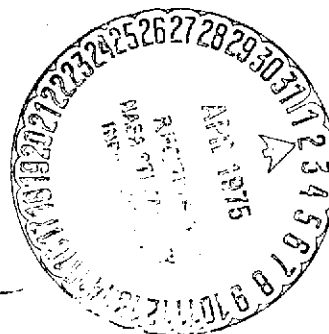
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INTERNAL FRICTION QUALITY FACTOR ≥ 3100 ACHIEVED IN LUNAR ROCK 70215,85

Previous studies have shown that very small amounts of absorbed volatiles-only removed by outgassing in high vacuum and elevated temperatures-drastically increase the internal friction in terrestrial analogs of lunar basalt (1,2,3). Recently (3) room temperature Q values as high as 2000 have been achieved by thorough outgassing procedures in 10^{-8} torr. Here new results are presented on Q measurements for lunar rock 70215,85, along with some data on the effect on Q of a variety of gases. This work shows that substantially greater increases in Q are obtainable in a lunar rock sample than in the terrestrial analog samples studied, and that in addition to H_2O other gases also can make non-negligible contributions to the internal friction.

1. Q-measurements in lunar rock 70215,85

Lunar sample 70215,85 ($0.4 \times 0.6 \times 8.5 \text{ cm}^3$) is a fine-grained sub-variolithic basalt with microphenocrysts of ilmenite, olivine, and clinopyroxene (4). As shown in Table I, when received the sample gave a $Q \approx 60$ in laboratory air. This value was increased to $Q \approx 340$ by pumping down to 10^{-3} torr with a molecular sieve sorption pump, and to 800 following a series of thermal heat treatments starting with a slow heat-cool run and finishing with a rapid cool-down. This procedure was followed by a Vac-Ion pump down and another extended heat treatment, which gave a Q value of 2420. Finally after an extended period (1 week) of Vac-Ion pumping, a room-temperature $Q \approx 3130$ was achieved at 2×10^{-7} torr. This value of Q is substantially greater than that achieved in thoroughly outgassed terrestrial analogs and falls in the range of lunar seismic Q values reported (5). Why the hard-vacuum-Q of the lunar sample is so much higher has not yet been established. However, the probable presence of combined water (hydroxyl group) within the structure and of liquid and gas inclusions in microscopic closed cavities must be held accountable for some of the loss in Q in the terrestrial rock. These sources of H_2O , completely absent on the lunar rock, are not removed by the heat treatments ($\sim 300^\circ\text{C}$) given the rocks in the present experiments.

2. Nature of Volatiles

In order to find out which volatiles are playing a role in the damping mechanism, carefully controlled experiments were undertaken with the few gases most likely to have been present in the lunar environment. The effect of CO_2 , CO, H_2 , and H on Q was measured for an analog of a lunar basalt as shown in Table II. The sample was first outgassed at 300°K and 10^{-8} torr to $Q \approx 500$, then suddenly exposed to one atmosphere of the gas, with the decrease in Q monitored with time. An inert gas, He, was used as reference gas for calibration purposes. The He gas was seen to have little or no effect, while CO_2 , CO, H_2 , and H definitely reduced the Q. The experiment with H was carried out by heating the sample to 170°C to cause dissociation

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of the molecular hydrogen. By comparison with the effect of H_2O (changes by factors of 10^2), the decrease in Q is small for these gases. This experiment was more sensitive than our previous test of the influence of various volatiles (2), largely because the sample was much more thoroughly outgassed initially. Residual gas analysis carried out at 10^{-8} torr after bake-out revealed the presence of equal amounts by volume of H_2O and CO in the test chamber. This result shows that H_2O is still probably the most serious factor preventing the achievement of higher Q -values.

Table I

Values for Q and Resonance Frequency
 for Lunar Rock 70215,85

Q (kHz) ν_{RES}	Outgassing Conditions
60 19.969	As received in laboratory air.
340 20.335	At 10^{-3} torr and room temperature.
400 20.353	After first heating run at 10^{-3} torr followed by slow cooling.
800 20.253	After second and third heating runs at 10^{-3} torr followed by rapid cooling.
2420 20.138	After fourth heating run followed by rapid cooling at 10^{-6} torr.
3130 20.661	After continued pumping at room temperature and at 10^{-7} torr.

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Table II

Effect of gases on Q in terrestrial
analog of lunar basalt

Gas at 1 atm. and room temp.	Reduction in Q
He	3%
CO ₂	8%
H ₂	25%
H	40%
CO	45%

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